Stanislav MIŠÁK, Jaroslav ŠNOBL, František DOSTÁL
VSB – Technical University of Ostrava

Power solutions for emergency lighting of tunnels, underpasses and ecoduct

Abstract. *In this paper, once of possibilities of an independent power supply emergency lighting of tunnels. Power should be provide by a combination of renewable resource (photovoltaic panels, wind power). This paper aims to estimate the investment costs of such a project and compare them with commonly used UPS (genset). Concrete concept for a hybrid system will be implemented for Klimkovice tunnel.*

Streszczenie. *W artykule tym przedstawiona jest jedna z możliwości niezależnego zasilania oświetlenia awaryjnego tuneli. Zasilanie miało by być zabezpieczone kombinacją odnawialnych źródeł energii elektrycznej (panele fotowoltaiczne, elektrownie wiatrowe). Celem artykułu jest oszacowanie nakładów inwestycyjnych na projekt tego typu i porównanie ich z kosztami standardowo używamych źródeł zapasowych. Konkretny projekt systemu hybrydowego będzie realizowany w Tunelu Klimkowickim.* ***(Rozwiązanie zasilania oświetlenia awaryjnego tuneli, przejść podziemnych i ekoduktów).***

Keywords: tunnel lighting, emergency lighting, solar power station, wind power station, hybrid power source, energy balance.
Słowa kluczowe: oświetlenie tunelu, oświetlenie awaryjne, elektrownia słoneczna, elektrownia wiatrowa, system hybrydowy, bilans energetyczny.

Introduction

Renewable energy resourses have passed expansion not only in the Czech Republic but also around the world. Many companies deal with their development and improvement, they also try to use them in various applications. Generation electricity based on wind energy or solar radiation is very ecological, it is modern and economical advantageous too in the last time. Whether it is true is the task of this article, which is going to focuse on once of the many areas of possible applications of these resources, especially their use like the emergency escape lighting of tunnels and underpasses.

The need of artificial lighting in tunnels depends on its length and sinuosity. According to these parameters we divide tunnels to:

- shorts (lighting depends on the visibility through the tunnel and sinuosity),
- optically longs (especially shorter tunnels, through them is not seen),
- geometrically longs (always require artificial lighting).

For long tunnels there are several types of electrical equipment, which can be divided according to type designation:

- switchboards power fan drive,
- switchboards accommodative lighting,
- switchboards transit lighting,
- switchboards emergency lighting,
- switchboards UPS power supply.

Energetic system of most tunnels is supplied by electricity energy of two independent resources - two independent substations. The control system provides function of automatic connection of UPS. His purpose in the case of power failure lighting system is to provide backup of the system, so to road users is given sufficient time to vacate the tunnel for the reduced rate transit. One possilbility of a backup system is using hybrid power supply from renewable sources of energy that will recharge batteries providing emergency state and in their full charging, then directly supply power to the grid.

Statistical data on consumption

For a particular design is chosen Klimkovice tunnel (see Fig.1.) near Ostrava, which has a length of 1088 meters and was put into operation in 2008. According to the recommendation should be installed in each tunnel tube lighting, which in case of fire, leads persons to the nearest escape exit, it is called emergency escape lighting. It is used for lighting a fire escape routes in the tunnel. This emergency lighting in this case consists of 12W diode lights embedded in the holes in the lining on both sides of the tunnel tubes and serves as an indication and alarm function, as shown in Fig. Emergency lighting must correspond to prescribed values by TP98/2004 E_m = 2lx.

Fig.1. Klimkovice tunnel [3]

For using of LED technology speaks almost unlimited life of lamps and minimum consumption in comparison with high light output.

Because of the potential smoke of upper area of the tunnel are these lights, in regard to illuminate the sidewalk, as escape routes, located 0,9 meters above the sidewalks. Pitch lights emergency escape lighting is 12 meters. Furthermore, these lights for emergency escape lighting SOS boxes are located in the building walls at the entrances to cross passages, where higher illuminance E_m = 5lx is required.

Such lighting must be supplied from an independent, uninterruptible power supply power energy, for example diesel generator, and emergency lighting must be in compliance with ČSN monthly checked by function test and conducted operation log of these tests. The minimum period of advance work resources must be 120 minutes. For Klimkovice tunnel is used of 368 lightings, which together makes an installed power 4,42kW (see Table 1.)

Fig.2. Example of LED tunnel exit emergency lighting [4]

Table 1. Data on consumption of lighting Klimkovice tunnel

Total installed power lighting	275,25kW
Emergency escape lighting	4,42kW

Advantages of the hybrid system

In recent times becomes a major hit to build wind and solar power at different places and use it for various applications. Construction of renewable energy sources, however, slowly starting to run into problems associated with free capacities of electrical distribution networks, and difficulties in providing support services and problems with retrospective effect on the grid. Isolated island systems therefore appears to be a useful supplement to meet the limits for the share of renewables in electricity production by the EU directives and without the above mentioned negative effects on the electricity grid. The production limits set for the Czech Republic has achieved the end of 2010 eight percents of total electricity production in mid-2009 the share of renewable energy production a little over six and half percents.

Installed capacity of island systems, is ranging from hundreds of watts to megawatts units. It is used to power appliances in cases where for various reasons difficult to dig and ask and electrical connection to connect devices to the grid. It is necessary to supply the outlying residential buildings, meteorological stations and tunnels in the very remote mountain ranges.

It is very important to choose the optimal renewable resource with regard to geomorphological and weather conditions of the site. As the optimal solution, therefore, seems a combination of wind and solar power. The advantage of this hybrid system is the mutual substitution of renewables such a way that in the winter, when the intensity of solar radiation and therefore lower, photovoltaic panels supply lower amounts of electricity, wind velocity reaches higher values and thus electrical energy is distributed mainly from wind power. On the other hand, in summer the situation is completely reversed, the intensity of solar radiation is higher and so the most of the electricity is generated in photovoltaic panels. Thanks to such mutual assistance of both sources may not be the final system too big, as it would have to be in the case of using only one source.

Analysis of the hybrid system

We will base on the installed power of 4,42kW emergency exit lighting. The consumption of lighting for the necessary period of 120 minutes is 8840Wh. Luminaires should be powered via UPS, so that was in operation during power failure of energy, or in case of fire. Power lights is on its own source voltage 24V, which is located outside of the lamp in a separate box. The performance of this source must be sized according to the quantity and wattage fixtures involved. For these voltages are sufficient to four gel, maintenance-free batteries series-parallel actuated. The capacity of each is 200Ah 12V with output voltage. Total capacity UPS for emergency escape lighting will therefore 400Ah.

This set of batteries will be supplied from the aforementioned combination of renewable resources, consisting of photovoltaic panels and wind power. If we are considering wind power utilization of twenty percents is sufficient to our pursuit of 20kW, with photovoltaic panels is a factor in the use of only about eight percents because we are considering the installed capacity of panels 6kWp. The type of solar panels depends on where the system will be implemented, for sunny areas are better suited monocrystalline panels and for areas with diffuse radiation are preferred polycrystalline technology, which is in the calculation and design under consideration. The system is designed so that when are fully charged the batteries supplies the energy and current-day operations of emergency lighting exit. The proposal also includes elements required to regulate power from renewable resources and facilities for the modification of parameters such as power rectifier and inverter. The following table (see Table 2.) is a rough estimate of costs of the entire system.

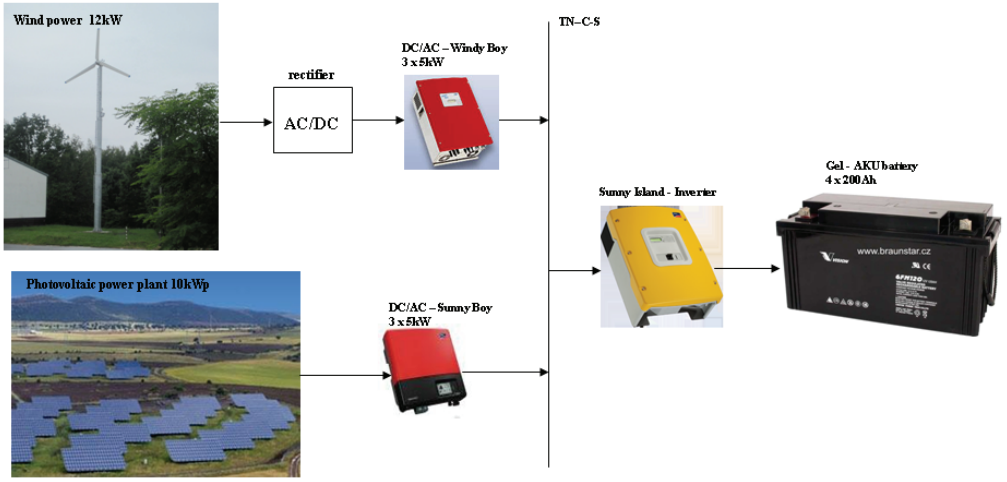

Fig.3. Schema diagram of a hybrid system

Table 2. Rough estimate of investment costs of a hybrid system

The various components of the system	Parameters	Valuation CZK	Number of units	Total CZK
AKU -gel batteries	12V/200Ah	12 000	4	48 000
Photovoltaic panels	polycrystalline, 210Wp	13 000	48	624 000
Wind power	12kW	1 200 000	1	1 200 000
Inverters	6 x 5kW	65 000	6	390 000
Rectifier	12kW	70 000	1	70 000
Regulator	do 100kW	90 000	1	**90 000**
Rough estimate of the price of CZK 2,422 million				

Conclusion

The concept of hybrid systems is applicable wherever it is not commonly available distribution network, and where it would be very difficult to keep cable lines. For such an imaginary case, we simulated the proposal for a combined system for Klimkovice tunnel and back up of the emergency exit lighting. This tunnel is 1089 meters length and the total electricity consumption for lighting is very difficult for the possible implementation and useing of a hybrid system. The final financial calculations would be almost a hundred times exceeded than the commonly used system for backup power in the form of diesel.

Combining renewable sources should has much better importance of the technical and financial terms for smaller buildings, in which installed power for lighting moves to 1kW. This means especially highway underpasses and upperbridges, ecoducts for animals and short tunnels, where the initial investment would be comparable to other alternative power options.

Acknowledgement

This article was created under project SP/201073, “Využití hybridních obnovitelných zdrojů elektrické energie”.

REFERENCES

[1] Mišák, S., Prokop, L.: Analysis of technical and economic parameters of hybrid systems. In 11th International Scientific Conference Electric Power Engineering 2010; (EPE 2010), 2010.

[2] Novák T., Mišák S., Sokanský, K.: Use of renewable energy to power lighting fixtures. In 11th International Scientific Conference Electric Power Engineering 2010; (EPE 2010), 2010.

[3] Available from WWW: < http://www.eltodo.cz/informacni-servis/fotogalerie/fotogalerie-doprava.html>

[4] Available from WWW: < http://www.schreder.com/90-12-25-28/product/detail.aspx>

***Authors**: VŠB-TU Ostrava, Fakulta elektrotechniky a informatiky, katedra Elektroenergetiky,*
17.listopadu 15, 708 33, Ostrava-Poruba, www.fei.vsb.cz;
doc.Ing. Mišák Stanislav, Ph.D., tel: 597329308,
E-mail: stanislav.misak@vsb.cz
Ing. Šnobl Jaroslav, tel: 597329309,
E-mail: jaroslav.snobl@vsb.cz
Ing. Dostál František, tel: 597324198,
E-mail: frantisek.dostal@vsb.cz.